The Integumentary System

Dr. Ali Ebneshahidi
The Skin

• The integument system consists of the skin (cutaneous membrane) and its accessory organs.
• The skin is composed of three layers of tissue: the outer epidermis (made of stratified squamous epithelium), the middle dermis (made of fibrous connective tissue), and the inner subcutaneous layer or hypodermis (made of adipose tissue and loose connective tissue).
• Accessory organs include the hair (hair root and hair shaft), hair follicle, pili arrector muscle, sebaceous glands, sudoriferous glands, nails, and mammary glands.
Functions of the Integumentary system

1. protection

a) chemical factors in the skin:
Sebum (or oil) from the sebaceous glands is slightly acidic, retarding bacterial colonization on the skin surface.

Sweat from the sudoriferous glands is slightly hypertonic and can flush off most bacteria on the skin surface.

Melanin (skin pigment) from melanocytes avoids excessive ultraviolet radiation from penetrating the skin layers.
b) physical factors in the skin:

**Stratified squamous epithelium** in the epidermis layer provides a large number of layers of cells, preventing most bacteria invasion.

**Keratinized cells** in the stratum corneum layer of the epidermis provides a physical barrier against most invasion.

c) biological factor in the skin:

White blood cells such as **macrophages** destroy most invading bacteria and other foreign substances.
2. Excretion
waste materials such as ammonia, urea, and excessive salt are eliminated from sweating.

3. Body temperature regulation
Sweating by the sweat glands promotes evaporation, resulting in a loss of excessive body heat. Vasoconstriction by arterioles (small arteries) in the dermis layer provides a smaller surface area in the blood vessels, resulting in less heat loss. Vasodilatation by arterioles in the dermis layer provides a larger surface area in the blood vessels, resulting in greater heat loss.
4. Cutaneous sensation
Nerve receptors in the dermis layers detect sensations such as heat, cold, pain, pressure, and touch, allowing the body to be aware of these stimuli.

5. Vitamin D synthesis
Ultraviolet radiation in the sunlight activates a series of chemical reactions in the epidermis layer, resulting in the synthesis of vitamin D from the modification of cholesterol for the absorption of calcium.
Functions of the skin

• maintains homeostasis.
• prevents the body from the penetration of harmful substances.
• Prevents water loss (desiccation).
• help to regulate body temperature.
• contains nerve receptors for various sensations.
• synthesizes chemical substances such as keratin, melanin, and vitamin D.
• excretes waste materials such as ammonia, urea, and salts.
• produces skin pigment (melanin) in the epidermis and hair to avoid excessive penetration of UV radiation.
Epidermis

• Being made of stratified squamous epithelium, there is no blood vessels to supply nutrients to its cells.

• Nutrients from the arterioles in the dermis layer diffuse upward into the epidermis layer, especially to the stratum basale and spinosum layers.

• Cuboidal cells at the stratum basale (stratum germinativum) layer receive most of the nourishment. These cells reproduce rapidly using mitosis. New daughter cells will be pushed upward into higher layers, and they become flattened as they move upward.

• Squamous cells moving upward in the epidermis receive less and less nutrients as diffusion distance increases. By the time they form stratum corneum, the cells are dead and will be shed off from the skin.
**Stratum corneum**
Most superficial layer; 20–30 layers of dead cells, essentially flat membranous sacs filled with keratin. Glycolipids in extracellular space.

**Stratum granulosum**
Typically one to five layers of flattened cells, organelles deteriorating; cytoplasm full of lamellar granules (release lipids) and keratohyaline granules.

**Stratum spinosum**
Several layers of keratinocytes unified by desmosomes. Cells contain thick bundles of intermediate filaments made of pre-keratin.

**Stratum basale**
Deepest epidermal layer; one row of actively mitotic stem cells; some newly formed cells become part of the more superficial layers. See occasional melanocytes and dendritic cells.
• Epidermal cells in stratum granulosum and stratum corneum undergo “keratinization” to produce a protein called keratin, allowing these cells to be tough and waterproof. These cells are now called "karatinocytes" where they develop desmosomes between the cells and allow the epidermis to become a stronger physical barrier.

• **Four** layer of cells are found in the epidermis of the body surface: stratum basale, stratum spinosum, stratum granulosum, and stratum corneum. In the palms and soles, an extra layer beneath stratum corneum is formed, called stratum Lucidum.

• Specialized cells called melanocytes in the stratum basale layer produce the skin pigment, melanin. The number of melanocytes and the amount of melanin production are genetically inherited.
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Dermis

• made of fibrous connective tissue that contains arterioles for supplying nutrients (i.e. oxygen, glucose, water, and ions) to its structures and to the epidermis.

• also contains pili arrector muscles (made of skeletal muscle, under involuntary control) to wrinkle the skin and erect the hairs.

• contains nerves and nerve receptors to detect the sensations of heat, cold, pressure, touch, and pain.

• also contains hair follicles to develop the hair.

• contains sebaceous gland to secrete sebum onto skin surface, and sudoriferous glands to secrete sweat.
Hypodermis

– Made of adipose tissue and loose connective tissue.

– Collagen and elastic fibers in the loose connective tissue are continuous with the fibers in the dermis layer.

– Adipose tissue serves as a heat insulator against cold climate and as a fat storage.

– Loose connective tissue allows the skin to be bound with underlying muscles.

– Also contains large blood vessels (arteries and veins).
Hair shaft

Epidermis
- Papillary layer

Dermis
- Reticular layer

Hypodermis
- Subcutaneous tissue; not part of skin

Appendages of skin
- Eccrine sweat gland
- Arrector pili muscle
- Sebaceous (oil) gland
- Hair follicle
- Hair root

Nervous structures
- Sensory nerve fiber with free nerve endings
- Lamellar corpuscle
- Hair follicle receptor (root hair plexus)

Dermal papillae
- Subpapillary plexus
- Sweat pore

Cutaneous plexus
- Adipose tissue
Accessory structures of the skin

1. Hair

– produced by epithelial cells at the **hair papilla**.
– made of keratinized cells.
– consists two regions: **hair root** (in the hair follicle, embedded in the dermis layer), and **hair shaft** (protruded through the epidermis to the outside).
– Hair pigment (melanin) is produced by melonocyets in hair papilla.
– Hair growth is affected by nutrition and hormones (i.e. testosterone).
(c) Diagram of a longitudinal view of the expanded hair bulb of the follicle, which encloses the matrix.
(a) Diagram of a cross section of a hair within its follicle

- Follicle wall
  - Peripheral connective tissue (fibrous) sheath
  - Glassy membrane
  - Epithelial root sheath
    - External root sheath
    - Internal root sheath

- Hair
  - Cuticle
  - Cortex
  - Medulla

- Hair shaft

- Arrector pili
- Sebaceous gland

- Hair root
- Hair bulb
2. pili arrector muscle
- made of skeletal muscle, but under involuntary control.
- attached to each hair follicle, for erecting the hair.
- situations such as extreme emotions or extreme temperatures can activate its involuntary contraction, resulting in hair erection or skin wrinkling.
3. **Sebaceous gland**

- Oil gland that is made of modified cuboidal epithelium.
- Occurs all over the body except in the palm and sole.
- Attached to each hair follicle, so that sebum can be secreted into the hair root and diffuse upward.
- Sebum helps the skin and hair to be waterproof, and retards bacterial growth on skin surface (due to its acidity).
4. Sudoriferous gland

- sweat gland that secretes sweat to promote evaporation.
- found all over the body except the lips, nipples, and external genitalia.
- referred to as "tubular gland" where it is a long tubule coiled in the dermis layer, and uses a long duct to release sweat onto skin surface through a pore.
5. Nails

- scale like modification of epithelial cells in the epidermis.
- made of keratin.
- Protect ends of fingers and toes and prevent over sensitization of the never receptors in extremities.
- Growing cells are derived from a region at base of nail called “Lunule”.

- Lunule
- Lateral nail fold
- Free edge of nail
- Body of nail
- Eponychium (cuticle)
- Root of nail
- Hyponychium
- Nail bed
- Phalanx (bone of fingertip)
Burns

- First degree burns: only the epidermis is damaged with redness and swelling.
- Second degree burns: epidermis & upper region of dermis is involved. There is Redness, swelling, and blisters.
- Third degree burns: all layers of skin burned (most severe). Skin graft is necessary to repair.
- Skin looks cherry red or black.
(a) Skin bearing partial-thickness burn (1st- and 2nd-degree burns)

(b) Skin bearing full-thickness burn (3rd-degree burn)
Anterior and posterior head and neck, 9%
Anterior and posterior upper limbs, 18%
Anterior and posterior trunk, 36%
Perineum, 1%
Anterior and posterior lower limbs, 36%

100%
Skin Cancer

• Most skin tumors are benign.
• Cause of cancer is unknown, but probably due to overexposure to ultraviolet radiation in the sunlight.
• Three main types of skin cancer:
  • **Basal cell carcinoma**
  • The most common type of skin tumor; usually benign.
  • Cells of stratum basale are affected, as a result they cannot form keratin and begin to invade into the dermis.
• Surgical removal (given that early detection is done) is 99% successful.
**Squamous Cell Carcinoma**
- arises form keratinocytes in stratum spinosum.
- mostly in the scalp, ears, or hands.
- grows and migrates rapidly.
- early detection is critical for successful treatment.

**Malignant Melanoma – most dangerous**
- cancer of the melanocytes in stratum basale.
- only 5% of all skin cancer, but the frequency is increasing.
- grow and migrates extremely rapidly.
- usually deadly.

Note: To avoid these skin tumors, it is advised that we should stay away from the sun during its most intense periods (10 am to 2 pm).
(a) Basal cell carcinoma  
(b) Squamous cell carcinoma  
(c) Melanoma

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Clinical Terms

- **Albinism** – inherited, melanocytes do not produce melanin.
- **Boils and carbuncles** – inflammation of hair follicles and sebaceous glands, infection spread to dermis.
- **Contact dermatitis** – itching and redness and swelling forming blisters. It is caused by chemical burns.
- **Psoriasis**: characterized by reddened epidermal lesions covered by dry silvery scales.
- **Rosacea**: redness of skin around eyes and nose accompanied by rash – like lesions. It gets worse with alcohol, hot H₂O, and spicy food.
- **Vitiligo**: skin pigmentation disorder caused by loss of melanocytes and uneven dispersal of melanin (unpigmented skin surrounded by normally pigmented areas).